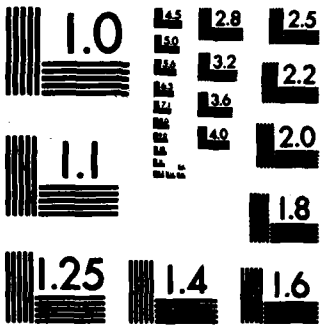
AD-A154 430 TRANSIENT COMBUSTION DYNAMICS(U) UNIVERSITY OF SOUTHERN CALIFORNIA LOS ANGELES P R CHOUDHURY ET AL. 26 JUN 84 AFOSR-TR-85-0380 AFOSR-82-0222 1/1

UNCLASSIFIED F/G 21/2 NL



TRANSIENT COMBUSTION DYNAMICS

(AFOSR Grant 82-0222)

Principal Investigators: P. Roy Choudhury and Melvin Gerstein

University of Southern California
Los Angeles, California 90089-1453

ANNUAL TECHNICAL REPORT (JUNE 1, 1983 - MAY 31, 1984)

SUMMARY

The characteristics of pressure fluctuations due to the instability of the shear layer at the sudden expansion step of a dump combustor are being studied experimentally. Results ~~to date~~ show that the disturbances induced by the step are centered around a characteristic frequency which is a function of the shape of the chamber. The center frequency appears to be independent of either the step height or the free stream velocity within the range of the experimental variables. The step height and the free-stream velocity affect only the amplitude and not the frequency of the disturbance. Closely spaced frequencies around the center frequency lead to a low frequency "beating" phenomenon which is clearly seen on an oscilloscope. Axisymmetric and two-dimensional chambers have different characteristic center frequencies and beat frequency distributions. This coherent beating appears to be responsible for the low frequency combustion instability in dump combustors. Work is continuing in order to understand the nature of the coherent beating and its influence on the combustor. A feedback control is to be used to destroy the coherence of the critical "beating" and minimize the effect of combustion instability.

TECHNICAL DISCUSSION

The objective of this program is to study the interaction of the pressure oscillation at the inlet of a dump combustor and the various existing vortices in the flow field. Such mutual interactions lead to a low frequency combustion instability in the form of large amplitude, coherent pressure oscillation in the chamber which disrupt the operation of the combustor. As a part of this study a feedback control system is to be proposed which can sense the onset of the combustion instability and by means of either gas jets or mechanical actuators destroy the coherent structure of the vortices and thereby minimize the effect of combustion oscillation. This study is aimed at understanding the fundamental causes of vortex-induced combustion instability and investigating a novel concept of minimizing its effect.

Experiments at USC and elsewhere show that coherent vortex shedding at the dump plane due to the inherent instability of the shear layer induces a low frequency pressure oscillation in the combustion chamber. Also if one is able to change the characteristics of the shear layer, rough burning ceases. This observation is the basis of the proposed feedback control system for minimizing the effect of combustion oscillation.

During the last grant period it was found that the interaction of vortices showed a "beat" phenomenon on the p-t history of the chamber. When the beating was reinforced by the induced pulsing, combustion instability resulted. By using a bandpass filter the distribution of beat frequencies were obtained by photographic means. At a given flow velocity the beat frequency distribution associated with the vortices at the step depends upon the step height and the chamber geometry. For the present 2-D chamber under cold flow conditions, the beating originates from frequencies in the neighborhood of 1.9 khz (Fig. 1). The resulting mean of the frequency distribution is in the range of 70-100 hz and it coincides with the observed critical pulsing frequency. No beating was observed without the step (e.g. with only a flat plate). The amplitude of pressure increased with the step height (maximum at 1.3 cm for the chamber) and then decreased. For a 7.6 cm axisymmetric chamber, the beats originate from frequencies near 2.3 khz and the amplitude reaches a maximum at a step height of .6 cm. The air supply also causes beating originating in the frequency range of about 430 hz. Induced pulsing at the mean of the distribution of frequencies ($\sim$ 350 hz) did not result into rough burning indicating that the beating caused by the sudden expansion step is the primary cause of rough burning. Attempts are being made, however, to eliminate the blower disturbance by means of a large plenum chamber. Preliminary results show that the critical center frequencies associated with the sudden expansion step are not affected by the blower disturbance centered around 430 hz. Thus, these frequencies are characteristics of the sudden expansion process.

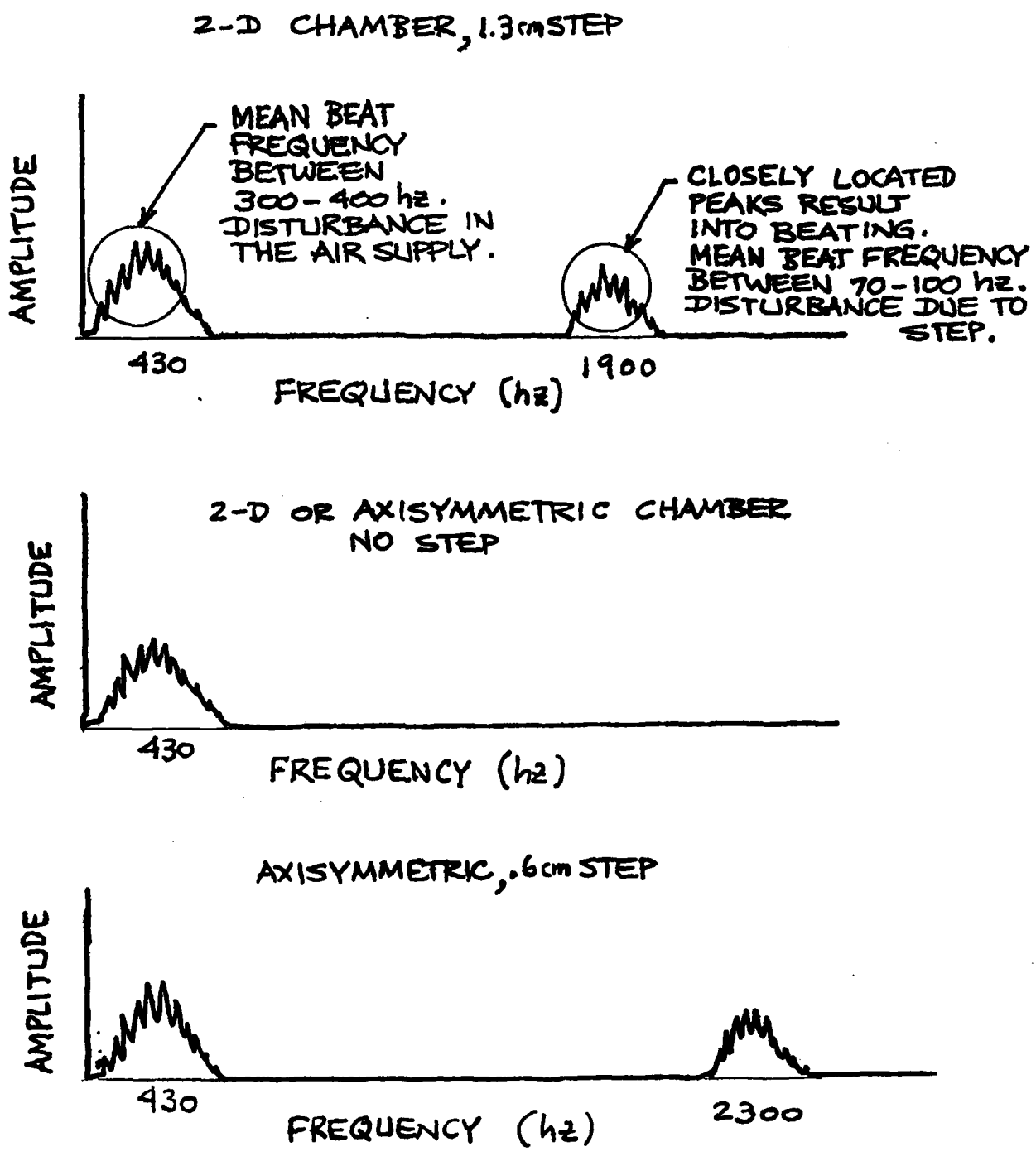


FIGURE 1. SKETCHES OF TYPICAL DISPLAYS FROM A FREQUENCY ANALYZER. COLD FLOW.

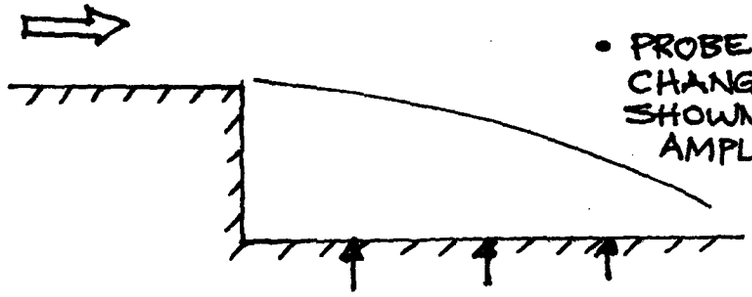


FIGURE 2. THREE DIFFERENT RELATIVE LOCATIONS OF THE PRESSURE TRANSDUCER.

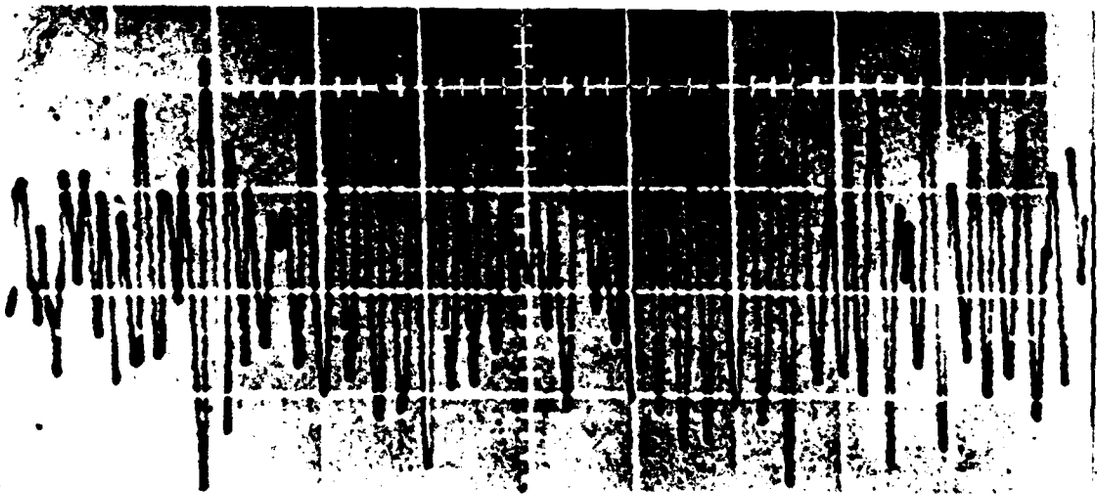


FIGURE 3. A TYPICAL p-t TRACE SHOWING 'BEAT' DUE TO THE STEP. 5 ms/DIVISION; 0.21 KPa/DIVISION; 61.0 m/sec. HOT FLOW.

PROFESSIONAL PERSONNEL

i) Co-Principal Investigators

Drs. Melvin Gerstein and P. Roy Choudhury

ii) Graduate Assistants

Mr. Reza Mojaradi

Mr. H. Rowshani

iii) Undergraduate Students

Mr. John Roberts

Mr. Lee Yamamoto

Mr. Brian Wilson

Mr. Doug Wolff

iv) Graduate Student

Tomi Mossessian

LIST OF PUBLICATIONS June 1, 1983 - May 31, 1984

The following publications resulted from the topics on fuel decomposition which are not included in the current grant.

1. Choudhury, P.R., Gerstein, M. et at "Slurry Fuel Droplet Breakup by Irradiation at Discrete Frequencies" Paper No. AIAA 83-1142, AIAA/SAE/ASME 19th Joint Propulsion Conference, Seattle, June 27-29, 1983.

2. Gerstein, M. and Choudhury, P.R., "Timed Ignition of Explosives and Flammables from Desensitized Solutions" 9th International Colloquium on Dynamics of Explosions and Reactive Systems. Poitier, France, July 3-8, 1983. To Appear in Progress in Aeronautics and Astronautics.

3. Choudhury, P. Roy and Gerstein, Melvin, "Effects of Liquid Phase Decomposition on Fuel Droplet Distribution Function," To Appear in the Nov. 1984 issue of AIAA Journal. (Also presented at the 21st AIAA Aerospace Sciences Meeting, Reno, Nevada, Jan. 1983).

4. Gerstein, M. and Choudhury, P. Roy, "Use of Silane/Methane Mixtures for Scramjet Ignition," AIAA/SAE/ASME 20th Joint Propulsion Conference, Paper No. AIAA-84-1407, Cincinatti, Ohio, June 11-13, 1984.

INTERACTIONS

Reference 1. Dr. Ben Zinn, Georgia Tech
Mr. Mike Beltran, Beltran Associates, New York
Atlantic Research

Reference 2, 4, NASA Lewis Dr. G.B. Northam
Dr. H.L. Beach
ONR Dr. A. Wood/Dr. C. K. Law
Northwestern
Dr. F. Dryer, Princeton
So. Calif. Gas Co.
Rocketdyne

ADDITIONAL COMMENTS

Our present work which has demonstrated the importance of vortex interactions and identified beat frequencies resulting from frequency interactions has uncovered a new facet of instability ignored by previous investigations.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: Unclassified	1b. RESTRICTIVE MARKINGS:
2a. SECURITY CLASSIFICATION AUTHORITY:	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE:	
4. PERFORMING ORGANIZATION REPORT NUMBER(S):	5. MONITORING ORGANIZATION REPORT NUMBER(S): AFOSR-TR- 85-0380
6a. NAME OF PERFORMING ORGANIZATION: University of Southern Calif. / 6b. OFFICE SYMBOL (If applicable):	7a. NAME OF MONITORING ORGANIZATION: Air Force Office of Scientific Research/NA
6c. ADDRESS (City, State and ZIP Code): Los Angeles, Calif. 90089-1453	7b. ADDRESS (City, State and ZIP Code): Bolling AFB, DC 20332-6448
8a. NAME OF FUNDING/SPONSORING ORGANIZATION: AIR FORCE OFFICE OF SCIENTIFIC RESEARCH / 8b. OFFICE SYMBOL (If applicable): NA	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: AFOSR 82-0222
8c. ADDRESS (City, State and ZIP Code): BOLLING AFB DC 20332-6448	10. SOURCE OF FUNDING NOS.

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UI NO.
61102F	2308	A2	

11. TITLE (Include Security Classification): Transient Combustion Dynamics

12. PERSONAL AUTHOR(S): Choudhury, P. Roy and Gerstein, Melvin

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Annual	FROM 6/1/83 TO 5/31/84	1984, 6-26	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB. GR.	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The characteristics of pressure fluctuations due to the instability of the shear layer at the sudden expansion step of a dump combustor are being studied experimentally. Results to date show that the disturbances induced by the step are centered around a characteristic frequency which is a function of the shape of the chamber. The center frequency appears to be independent of either the step height or the free stream velocity within the range of the experimental variables. The step height and the freestream velocity affect only the amplitude and not the frequency of the disturbance. Closely spaced frequencies around the center frequency lead to a low frequency "beating" phenomenon which is clearly seen on an oscilloscope. Axisymmetric and two-dimensional chambers have different characteristic center frequencies and beat frequency distributions. This coherent beating appears to be responsible for the low frequency combustion instability in dump combustors. Work is continuing in order to understand the nature of the coherent beating and its influence on
(continued on reverse side)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE NUMBER (Include Area Code)	22c. OFFICE SYMBOL
JULIAN M TISHKOFF	(202) 767-4935	AFOSR/NA

DD FORM 1473, 83 APR — EDITION OF 1 JAN 73 IS OBSOLETE. — UNCLASSIFIED SECURITY CLASSIFICATION OF THIS

the combustor. A feedback control is to be used to destroy the coherence of the critical "beating" and minimize the effect of combustion instability.

END

FILMED

6-85

DTIC